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TITLE

MOTOR FUEL FOR DIESEL, GAS-TURBINE
AND TURBOJET ENGINES

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BACKGROUND OF THE INVENTION

This application is a continuation of International
Application Nos. PCT/SE99/01546, filed on September 6,
10 1999, and PCT/SE00/01717, filed on September 6, 2000.

Field of the Invention

The present invention relates to motor fuel suitable,
15 for example, in diesel, gas-turbine, and turbojet
engines, and especially in standard engines. This
motor fuel includes fuel compositions of organic
compounds containing bound oxygen, and, optionally,
hydrocarbon compounds. In addition, this invention
20 relates to fuel compositions that are stable,
homogeneous liquids under normal operating conditions
of the engines mentioned above.

Background to the Invention

Reduction of pollutants in exhaust emissions of diesel engines represents a challenge to modern society. It has been proposed to replace diesel oil, for example, EN 590 and No. 2 diesel oil, and the like, as a fuel for vehicles, because of environmental reasons and also due to its effects on health. There are international agreements providing for the progressive tightening of the requirements concerning the amount of toxic products resulting from combustion of motor fuel in the exhaust emissions of vehicles and other machines using diesel engines. In the European Union countries and in the United States, the requirements of Step II come into effect in the year 2002. Such requirements mandate a significant decrease in carbon monoxide (CO), mixtures of hydrocarbons and nitrogen oxides (HC+NO_x), and particles in the exhaust emissions of diesel engines.

Moreover, modern society is preoccupied with the ameliorating the global imbalance of carbon dioxide in the atmosphere, which is linked to the intensive burning of petroleum products, coal and fossil gas. The damage to the carbon dioxide balance in the atmosphere causes global climate warming and has a negative influence on our planet.

In this regard, the development of motor fuel for engines obtained from renewable plant resources is of real significance.

The growing concern for the protection of the environment and stricter standards in the content of harmful components in exhaust emissions forces the industry to develop urgently various alternative fuels
5 that burn more cleanly than the ones that are in use today.

The existing global inventory of vehicles and machinery with standard diesel, gas-turbine and turbojet engines
10 does not currently the complete elimination of hydrocarbon mixtures obtained from mineral resources, for example crude oil, coal and natural gas, as motor fuel. Diesel oil is such a hydrocarbon mixture.

15 On the other hand, it is possible to replace a portion of hydrocarbons in motor fuel, such as diesel oil, with other organic compounds that provide cleaner exhaust emissions and do not adversely affect engine performance. Gasolines comprising oxygen-containing
20 compounds are widely used. It is also known, for instance, that replacing 15% of the diesel oil by alcohol in motor fuel results in cleaner exhaust and provides acceptable power without modification of existing diesel engines.

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However, the problem of using the most widely available and inexpensive alcohols, methanol and ethanol, as a portion of a motor fuel is that these compounds are immiscible with diesel and gas oil fuels. Potentially,
30 alcohols and other oxygen containing compounds should yield environmentally clean products of combustion. However, the combustion process in engines is an

extremely complicated phenomenon, which is affected not only by the composition of the fuel, but also by the physical parameters of the fuel, and, initially by the homogeneity of the liquid.

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The feasibility and properties of mixtures of petroleum diesel fraction with ethanol was reported in Technical Feasibility of Diesohol, ASAE Paper 79-1052 in 1979.

It was stressed in that article that the main problem related to using such a fuel is its tendency for phase separation. Furthermore, the phase separation is significantly affected by the presence of water in the system. At 0°C, a water content of only 0.05% causes separation of a motor fuel consisting of 99% diesel and

15 0.95% ethanol.

It is widely known that NO_x emissions can be reduced by reducing the combustion temperature. One way to achieve this reduced combustion temperature is to add water to the fuel or to separately inject water in the combustion chamber.

However, by adding water phase separation will occur in most fuel systems, especially at lower temperatures, for example below 0°C. EP-A-0 014 992 (BASF) and U.S. Patent No. 4,356,001 (Sweeney '001) address the problem of water in the fuel composition by including in the fuel polyethers and/or acetals with or without methanol or ethanol. However, when formulating fuel compositions according to the Sweeney '001 patent, one will find that the improved water tolerances are not sufficient in a wider temperature range. The emissions

of carbon monoxide, hydrocarbons and soot from such fuels are significantly higher than acceptable emissions.

- 5 It is known that alcohol-containing fuels provide relatively low emissions of carbon, carbon oxide and nitrogen oxide (Johnson R.T., Stoffer J.O., Soc. Automot. Eng. (Spec. Publ.) 1983, S.P. 542, 91-104).
- 10 A significant part of the developments in the field of hybrid diesel fuels is dedicated to the creation of microemulsions. Microemulsions are thermally stable colloid dispersions in which the particle diameter is on the order of 20-30 Å. In 1977, Backer proposed
- 15 employing surfactants to form microemulsions of alcohols and hydrocarbons (GB Patent No. 2,002,400). Later, for the same purposes, other emulsifiers were proposed (GB Patent No. 2,115,002; U.S. Patent No. 4,509,950; U.S. Patent No. 4,451,265; and European
- 20 Patent No. 475,620).

- It is possible to achieve a homogeneous composition of diesel fuel incorporating different alcohols and their mixtures. French Patent No. 2453210, to achieve a
- 25 homogeneous liquid incorporating hydrocarbons and methanol, proposed to add primary aliphatic saturated alcohols of linear and branched structures having from 8 to 15 carbon atoms or mixtures of such alcohols. The avoidance of the separation of the hybrid fuel
- 30 incorporating the alcohol mixture is also addressed by the European Patent No. 319060.

A study of the performance characteristics of the hybrid fuels confirms the possibility of their use for the operation of diesel engines (Mathur H.B., Babu M.K. Indian Inst. Techn. Journ. Therm. Eng., 1988, 2(3), p. 63-72. Haschimoto, K., et al., Journ. Jap. Petrol. Inst., 1996, v. 39, N2, p. 166-169).

To achieve a homogeneous fuel blend, WO95/02654 proposes using a formulation containing up to 20% of the total volume of ethanol and/or n-propanol, up to 15% of the total volume of fatty acid and/or organic ester, and the remainder comprised of a hydrocarbon liquid. The patent provides examples of compositions in which oleic acid, as well as different organic esters, are used in addition to diesel, ethanol and propanol.

In WO95/02654, all Examples are said to illustrate fuel compositions having a single phase to demonstrate the effectiveness of using certain amounts of fatty acids and/or organic esters, as well as their mixtures, to obtain homogeneous liquids incorporating diesel and low alkyl alcohols in addition to those mentioned above. However, this patent does not provide any temperature limits with regard to stability of the obtained fuel formulations, and is silent as to how the presence of water in the compositions affects stability.

In addition, WO95/02654 fails to teach or suggest use of at least two oxygen-containing organic compounds containing in total at least four specific functional groups.

- It is well known that stability of mixtures of lower alcohols and diesel is one of the main operational properties of such fuels. In WO95/02654, tests of several compositions in various standard diesel engines
- 5 did not show a decrease of power and efficiency of the fuel. However, nothing is said regarding the content of the exhaust emissions of different engines using the proposed fuel formulations. The only comment in that regard is that the use of the ethanol blend over
- 10 several months in the engine of a Yale Forklift (model GDP 050 RUAS) Mazda XA was likely to be more acceptable with regard to the condition of the air inside the warehouse where the forklift was operated.
- 15 The mentioned drawbacks of the fuel compositions of the prior art are eliminated by providing a fuel composition of the present invention.

- Contrary to a large number of fuel compositions of the
- 20 prior art that have been used to replace diesel fuel in part or in total, especially compositions containing carboxylic acids, the fuel of the present invention is essentially non-corrosive.

25 Summary of the Invention

- It is an object of the present invention to provide a motor fuel composition the use of which can result in a considerable reduction of pollutants in the exhaust
- 30 emissions, including emissions of NO_x , particles and excess carbon dioxide.

It is an additional object of the present invention to provide a motor fuel composition that can be obtained from renewable raw materials.

- 5 It is another object of the present invention to provide a motor fuel that may be used in existing, standard automobile or truck engines, including diesel engines, advantageously without any changes in fuel injection synchronisation, valve timing and valve
10 opening time.

It is yet another object of the present invention to provide a motor fuel composition that can allow switching between conventional fuels and fuels

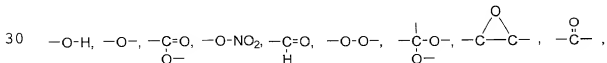
- 15 according to the present invention without any engine modifications.

It is a further object of the present invention to provide a motor fuel that will remain a homogeneous

- 20 liquid over a wide range of temperatures even if water is present.

The stable motor fuel composition of the present invention comprises:

- 25 (a) an oxygen-containing component comprising at least two oxygen-containing organic compounds, said oxygen-containing organic compounds containing in total at least four oxygen-containing functional groups comprising the following:



wherein each of said oxygen-containing organic compounds contains at least one of said oxygen-containing groups; and, optionally,

(b) a hydrocarbon component.

5

The motor fuel composition of the present invention can be used to reducing the deposits in a combustion chamber of an engine.

- 10 The motor fuel composition of the present invention may be prepared by successively introducing into a fuel reservoir at a constant temperature compounds comprising the motor fuel composition, beginning with a compound having a lowest density at said temperature
- 15 and terminating with a compound having a highest density at said temperature.

DETAILED DESCRIPTION OF THE INVENTION

- 20 In general, the oxygen-containing organic component is present in amounts from about 5% to 100% based on the total volume of the motor fuel composition and, when present, the hydrocarbon component is employed in amounts from 0 to about 95%, based on the total volume
- 25 of the motor fuel composition.

In general, the motor fuel composition is preferably stable at atmospheric pressure over a temperature range from a cloud temperature of as low as about -35°C to an

30 initial boiling temperature of about 180°C.

The preferred homogeneous motor fuel composition has a cloud point not higher than about -50°C and an initial boiling point not lower than about 50°C .

- 5 The motor fuel compositions of the present inventor will re-homogenize, if first brought to temperatures below the cloud point or to temperatures above the starting boiling point, so that a phase separation will occur, and then allowed to return to temperatures
- 10 within the temperature range between the cloud point and the initial boiling point of the specific fuel composition.

The motor fuel composition preferably exhibits at least

- 15 one, more preferably a portion, and, most preferably, all of the following properties:
- (i) density at 20°C of not less than 0.775 g/cm^3 ;
 - (ii) the cloud temperature is not higher than 0°C at atmospheric pressure;
 - 20 (iii) stable at atmospheric pressure from cloud temperature of 0°C to initial boiling point of 50°C ;
 - (iv) amounts of liquid evaporated by boiling at atmospheric pressure;
 - not more than 25% of the total volume of the
 - 25 motor fuel composition distills no higher than 100°C ;
 - not more than 35% of the total volume of the motor fuel composition distills at temperatures no higher than 150°C ;
 - 30 - not more than 50% of the total volume of the motor fuel composition distills at temperatures no higher than 200°C ;

- not less than 98% of the total volume of the motor fuel composition distills at temperatures no higher than 400°C, suitably no higher than 370°C; and preferably no higher than 280°C;
- (v) heat of combustion on oxidation by oxygen of not less than 39 MJ/kg;
- (vi) self-ignition temperature from 150°C to 300°C.
- (vii) ability to accommodate at least 1% water by volume.

- The motor fuel composition is preferably produced by successively introducing into a fuel reservoir at the same temperature, the components of the motor fuel composition beginning with the component having the least density at that temperature and terminating with the component having the highest density at that temperature.
- 20 A heavier hydrocarbon fraction may be employed in combination with the oxygen-containing components. The hydrocarbon fraction employed is generally any hydrocarbon mixture, such as a petroleum fraction, meeting ASTM specifications for diesel fuel. Depending
 - 25 on grade, actual hydrocarbon fractions will vary. No. 2 diesel fuel, having its European counterpart in EN 590 diesel fuel, is most commonly used in commercial and agricultural vehicles and, increasingly, in private vehicles. Of course, other hydrocarbon fractions
 - 30 lighter than the diesel fraction, including kerosene, as well as fractions heavier than the diesel fraction,

including gas oil and fuel oil, could be used in the present motor fuel, to replace the diesel fraction.

- The hydrocarbon component of the instant motor fuel composition, when employed, is preferably a diesel fraction. The diesel fraction is preferably a mixture of a diesel oil and the hydrocarbon fraction lighter than the diesel oil. It is also possible to employ a hydrocarbon liquid obtained from a renewable raw material as a component of the motor fuel for diesel engines. It is preferred to employ the hydrocarbon liquids obtained from turpentine or rosin, as well as hydrocarbon liquids produced by processing of oxygen containing compounds.
- 15 The hydrocarbon component of the motor fuel for diesel engines, when employed, can be produced from synthesis-gas, or natural gas and coal.
- 20 Examples of oxygen-containing components containing a total of at least 4 oxygen-containing functional groups include:
- ethanol
 - 2-ethoxyhexylglycidyl ether
- 25
- propanol
 - acetaldehyde diethyl acetal
 - formaldehyde diethyl acetal
- 30
- ethanol
 - methanol
 - tertbutyl peroxyacetate

propanol
methyl acetate
ethyl formate
ethyl oleate

5

tertbutyl peroxyacetate
isobutyl aldehyde
di-octyl ether
n-amyl nitrate
propanol

10

Preferably, at least one of methanol or ethanol, and, optionally, products derived from said methanol and/or ethanol, are present in the oxygen-containing compound
15 component. The components of the motor fuel may contain contaminants, which reduce the time and expense in processing the components for use in the fuel.

In a preferred embodiment of the invention, water
20 amounts up to about 1% based on the total volume of the motor fuel composition may be present without significantly and undesirably affecting the properties and homogeneity of the motor fuel compositions. Accordingly, commercially available components and
25 hydrocarbon fractions that contain water as a contaminant need not necessarily be treated to remove water prior to being incorporated in the motor fuel.

It is also a preferred feature of the invention to use
30 an oxygen-containing organic component from produced from a renewable plant resource.

According to a preferred embodiment of the invention, for a fuel composition providing a shorter delay period in the ignition of the motor fuel, the organic compounds containing bound oxygen preferably have a
5 linear or sparsely branched molecular structure. "Sparsely branched" may be understood to include compounds with only one side-chain.

According to another preferred embodiment of the
10 invention, the temperature of self-ignition of a fuel composition comprising organic compounds with bound oxygen in a branched molecular structure is between about 150°C and 300°C, so that the operation efficiency is not reduced.

15 In accordance with a further preferred embodiment of the invention a fuel composition is provided for an efficient operation of engines that results in reduction of pollutants in the exhaust emissions,
20 without the addition of hydrocarbons. For this purpose, only the organic compounds containing bound oxygen are employed.

An oxygen-containing component that completely replaces
25 hydrocarbon fuel can preferably comprise any two of tetrahydrofurfuryl alcohol, tert-butyl peroxyacetate, 1,2-epoxy-4-epoxycyclohexane and di-ethoxypropane. For example, such a motor fuel composition can comprise 67% tetrahydrofurfuryl alcohol and 33% tert-butyl
30 peroxyacetate.

Another oxygen-containing component that completely replaces hydrocarbon fuel can comprise i) one of methylepoxytallowate or 2-ethylhexylglycidyl ether and ii) one of ethanol, propanol, hexanol, dibutyl ether, 5 dihexyl ether, di-n-amyl ether, isopropyl nitrate.

The compounds that can completely replace hydrocarbon fuel are not limited to the examples presented above.

- 10 The instant motor fuel composition can be utilized under conditions of either reduced and/or increased ambient temperature with satisfactory efficiency in operation.
- 15 In accordance with a further preferred embodiment of the invention, oxygen-containing components can provide the required lubrication properties of the motor fuel, which are of particular importance for proper operation of a diesel engine. The lubricating properties may be
- 20 provided by esters with long hydrocarbon chains, preferably from 11 to 20 carbons. Such esters are preferably synthesized by reacting higher alcohols with lower acids or lower alcohols with higher acids.
- 25 According to another preferred embodiment of the invention, oxygen containing components reduce deposits in the combustion chamber of the engine.

The oxygen-containing component of the motor fuel of 30 the invention preferably includes (i) alcohols, (ii) ethers, (iii) organic esters and (iv) at least one of aldehyde, ketone, inorganic ester, acetal, epoxide and

peroxide, and, preferably, all compounds listed in (iv).

- 5 In a most preferred embodiment, the fuel composition of the invention comprises at least one compound of each of the different classes in groups (i) through (iv) above.

- 10 Mixtures of alcohols, such as (i) ethanol and butanol, (ii) ethanol, propanal and hexanol, (iii) methanol and ethanol, (iv) ethanol, butanol and hexanol and (v) ethanol, propanol, butanol, pentanol, ethyl-hexanol, and trimethylnonanol and the like may preferably be employed as the alcohol component. Further, mixtures
15 of ethers and mixtures of organic esters may also be utilized for the ether or organic ester component, respectively, with satisfactory results. Likewise, mixtures of any of acetals, epoxides, peroxides, aldehydes, ketones and inorganic esters may be employed
20 for such components.

- When a total of three or fewer oxygen-containing functional groups are employed to form the instant motor fuel composition for diesel engines, it has been
25 found that it is difficult to readily form a homogeneous, single phase fuel. For example, when diesel oil is combined with ethanol, oleic acid and isopropyl oleate, as in Composition 10 of WO95/02654, by adding to diesel oil ethanol, oleic acid and
30 isopropyl oleate. The mixture is permitted to stand for an hour, and a multi-phase composition is generally observed. Only with substantial shaking does the phase

separation disappear. To the contrary, in the present invention, where a total of four different oxygen-containing functional groups are employed in at least two oxygen-containing organic compounds and the components are mixed in order of increasing density and the mixture allowed to stand for at least about an hour, a single phase mixture is obtained without the need for additional mixing.

- 10 The oxygen-containing component can include an alcohol. In general, aliphatic alcohols, preferably alkanols, and mixtures thereof are employed. More preferably, alkanols of the general formula: $R-OH$, in which R is alkyl with 1 to 10 carbon atoms, most preferably 2 to 8 carbon atoms, such as ethanol, n-, iso- or sec-butyl, or amyl alcohol, 2-ethylhexanol, or 2,6,8-trimethyl-4-nonanol are employed.

- 20 The fuel additive can include an aldehyde of the general formula $R-\overset{\overset{O}{\parallel}}{C}-H$, where R is a C_1-C_8 , hydrocarbon.

- Preferred aldehydes include formaldehyde, 25 ethylaldehyde, butylaldehyde, isobutylaldehyde and ethylhexylaldehyde.

The fuel additive can include a ketone of the general formula $R-\overset{\overset{O}{\parallel}}{C}-R_1$, wherein R and R_1 each are a C_1-C_8

- 30 hydrocarbon residue, the same or different or, together, form a cyclic ring, the total number of

carbon atoms of R and R₁ being 3 to 12. The preferred ketones of the invention include diisobutyl ketone, ethylamyl ketone, carvon, and menthone.

- 5 The ether fuel additive preferably includes a monoether, a diether and/or a cycloether. A preferred ether has the general formula R-O-R', wherein R and R' are the same or different and are each a C₂-C₁₀ hydrocarbon group or, together, form a cyclic ring. In
10 general, lower (C₄-C₈) dialkyl ethers are preferred. The total number of carbon atoms in the ether is preferably from 8 to 16.

- Typical monoethers include dibutyl ether, tert-butyl
15 isobutyl ether, ethylbutyl ether, diisoamyl ether, dihexyl ether and diisooctyl ether. Typical diethers include dimethoxy propane and diethoxy propane. Typical cycloethers include cyclic mono, di, and heterocyclic ethers such as dioxane, methyl
20 tetrahydrofuran, methyl tetrahydropyran, and tetrahydrofurfuryl alcohol.

The ester additive may be an ester of an organic acid of the general formula

- 25
$$\begin{array}{c} \text{O} \\ \parallel \\ \text{R}-\text{C}-\text{O}-\text{R}' \end{array}$$
, where R and R' are the same or different. R and R' are preferably hydrocarbon groups. Preferably, they are C₁-C₈ alkyl esters of C₁-C₂₂ saturated or unsaturated fatty acids. Typical esters
30 include ethyl formate, methyl acetate, ethyl acetate, propyl acetate, isobutyl acetate, butyl acetate, isoamyl acetate, octyl acetate, isoamyl propionate,

methyl butyrate, ethyl butyrate, butylbutyrate, ethyl oleate, ethyl caprylate, rape seed oil methyl ester, isobornylmethacrylate and the like.

- 5 The acetal fuel additive can have the general formula:



wherein R is hydrogen or a hydrocarbon, preferably lower alkyl, i.e. (C₁-C₃) and R' is C₁-C₄ alkyl, such as methyl, ethyl or butyl. Typical acetals include

- 10 formaldehyde dimethyl acetal, formaldehyde diethyl acetal, acetaldehyde diethyl acetal and acetaldehyde dibutyl acetal.


The oxygen-containing compound of the invention can be

- 15 an inorganic acid ester; that is, an organic ester of an inorganic acid. A typical inorganic acid is nitric acid and the organic moiety can be a hydrocarbon, preferably alkyl or alicyclic. Typical examples of the inorganic acid ester include cyclohexyl nitrate,
20 isopropyl nitrate, n-amyl nitrate, 2-ethylhexyl nitrate, and iso-amyl nitrate.

The oxygen containing compound can be an organic peroxide. Typical organic peroxides are of the formula

- 25 R-O-O-R' where R and R' are each the same or different and can be, for example, alkyl or oxygen-substituted alkyl, such as alkanolic. Examples of organic peroxides include tert-butyl peroxyacetate and di-tert butyl peroxide. Because of the cleavage of the oxygen-oxygen
30 bond, in the present invention, a hydroperoxide is considered to have two oxygen-containing functional groups: an ether group and a hydroxy group.

The oxygen containing compound can be an organic epoxide. Typical organic epoxides have the general

formula  where R and R' are C₁ - C₁₂, and are the

- same or different and are hydrocarbons, preferably
5 alkyl and alkanolic. Typical epoxides include
1,2-epoxy-4-epoxy ethylcyclohexane, epoxidised methyl
ester of tall oil and ethylhexylglycidyl ether.

- The oxygen-containing fuel additives are employed in
10 effective amounts to provide a homogenous motor fuel
and an efficient fuel having reduced emissions.
Usually, at least about 5% by volume of oxygen
containing additive is employed. Further, a completely
hydrocarbon-free fuel, which is 100% oxygen-containing
15 component, can be employed.

- The minimum amount of any of the at least four
functional groups, calculated as the total volume of
the compound(s) exhibiting the particular group, should
20 not be lower than 0.1%, suitably not lower than 0.5%,
and preferably not lower than 1% of the total volume of
the fuel composition

- In general, the alcohol is preferably employed in
25 amounts from about 0.1 to 35% by volume; the aldehyde
in amounts from about 0 to 10% by volume, the ether in
amounts from about 0.1 to 65% by volume, the organic
ester in amounts from about 0.1 to 20% by volume, the
acetal in amounts from 0 to 10% by volume, the
30 inorganic ester in amounts from about 0 to 2% by

volume, the peroxide in amounts from about 0 to 2% by volume, and the epoxide in amounts from about from about 0 to 10%, although greater and lesser amounts can be employed depending on the particular circumstances
5 for a given motor fuel composition useful in a diesel engine.

The alcohol, or any other component of the fuel composition, may be present as a by-product contained
10 in any of the other components.

The organic compounds containing bound oxygen can be derived from fossil-based sources or from renewable sources as biomass.

15 As non-limiting examples demonstrating the effectiveness of this invention, the illustrative motor fuel compositions that are described hereafter are particularly suitable for the operation of diesel,
20 gas-turbine and turbojet engines, including standard types of engines, without any modification thereof.

EXAMPLE 1

25 Motor Fuel Composition 1 prepared below demonstrates that even when a very small quantity of organic compounds containing bound oxygen is employed, these compounds still provide a noticeable reduction of pollutants in the exhaust emissions of a standard
30 diesel engine.

The content by volume of components in the Motor Fuel Composition 1 is as follows: formaldehyde diethyl acetal - 1%; 1-butanol - 1%; di-n-amyl ether - 1.75%; octyl acetate - 1%; isopropyl nitrate - 0.25%; and 5 hydrocarbon liquid (diesel fuel according to standard EN 590) - 95%.

The fuel components were added to a common tank starting with the component with the lowest density and 10 ending with the component having the greatest density. The resulting motor fuel composition had the following characteristics:

	Density at 20°C	0.811 g/cm ³
15	Temperature limits of evaporation by boiling of the liquid at atmospheric pressure	
	up to 100°C	1%
20	up to 150°C	2.25%
	up to 200°C	14.5%
	up to 370°C	98.0 %
	Heat of combustion	42.8 MJ/kg
	Thermal stability	Motor Fuel Composition 1 was a homogeneous liquid, stable at atmospheric pressure over a range of temperatures from -18°C (cloud temperature) to 88°C (initial boiling temperature).

25

An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of the VW GOLF CL DIESEL automobile, engine family: D1-W03-92 when

executing Test Type, - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441 /EEC) on Motor Fuel Composition 1 showed a reduction in particles (g/km) of 5% compared to the results obtained for 100% diesel fuel (EN590:1993).

The use of Motor Fuel Composition 1 in the operation of a standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, for measurements over the range of 1000 - 2600 rpm, showed a decrease in the values of power and torque of less than 1% in comparison with the values obtained for the same engine operating on 100% diesel fuel (EN590:1993).

Similar results were obtained when employing the Motor Fuel Composition 1 for operation of the standard ship gas-turbine engine.

EXAMPLE 2

Motor Fuel Composition 2 produced a significant decrease of pollutants in the exhaust emissions of a standard diesel engine operating with an inexpensive fuel composition of organic compounds containing bound oxygen and a hydrocarbon liquid.

The content by volume of the components in Motor Fuel Composition 2 is as follows: ethanol - 3%; 1-butanol - 2.5%; dimethoxypropane - 3%; tetrahydrofuran - 1.5%; tert-butyl hydroperoxide - 0.5%; and hydrocarbon liquid (Mk1 diesel fuel SS 15 54 35) - 89.5%.

The fuel composition had the following characteristics:

- | | | |
|----|---|---|
| | Density at 20°C | 0.817 g/cm ³ |
| 5 | Temperature limits of evaporation by boiling of the liquid at atmospheric pressure: | |
| | up to 100°C | 8% |
| | up to 150°C | 10.5% |
| 10 | up to 200°C | 19.5% |
| | up to 285°C | 95.5% |
| | Heat of combustion | 41.9 MJ/kg |
| | Thermal stability | Motor Fuel Composition 2 is a homogeneous liquid, stable at atmospheric pressure over a range of temperatures from -30°C (cloud temperature) to 70°C (initial boiling temperature). |
- 15 An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC +
- 20 EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 2, in comparison with 100% Mkl diesel fuel (SS 15 54 35), showed a reduction in the amounts of CO (g/km) of 12%; HC+NO_x (g/km) of 5.75% and particles (g/km) of 11.5%.
- 25
- An analysis of the amount of the pollutants in the exhaust emissions from a standard diesel truck engine, Engine Type: VOLVO D7C 290 EUR02 No. 1162 XX, power

kw/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation for fuel composition 2, compared to 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amounts of: CO (g/kW) of 6%; HC+NO_x (g/kW) of 0%, and particles (g/kw) of 4%.

The power (PkW) of the engine when operating on Motor Fuel Composition 2 decreased only by 2.8%, and the fuel consumption (l/kW) slightly increased by 2% compared to the results obtained for the same engine operating on 100% Mk1 diesel fuel (SS 15 54 35).

EXAMPLE 3

Motor Fuel Composition 3 produced a significant decrease of pollutants in the exhaust emissions of a standard diesel engine operating with an inexpensive fuel composition of organic compounds containing bound oxygen and a hydrocarbon liquid, which was a mixture of hydrocarbons obtained from a synthesis-gas "synthin".

The content by volume of the components in Motor Fuel Composition 3 is as follows: ethanol - 3%; 1-butanol -2.5%; dimethoxypropane - 3%; ethyl acetate - 1.5%; tert-butyl hydroperoxide - 0.5%; and hydrocarbon liquid (hydrocarbon mixture obtained from synthesis-gas with catalyst under atmospheric pressure and temperatures of 170 - 200 °C) - 89.5%.

The fuel composition had the following characteristics:

- | | | |
|----|---|---|
| | Density at 20°C | 0.817 g/cm ³ |
| 5 | Temperature limits of evaporation by boiling of the liquid at atmospheric pressure: | |
| | up to 100°C | 7% |
| | up to 150°C | 10.5% |
| 10 | up to 200°C | 19.5% |
| | up to 285°C | 95.5% |
| | Heat of combustion | 41.7 MJ/kg |
| | Thermal stability | Motor Fuel Composition 3 is a homogeneous liquid, stable at atmospheric pressure over a range of temperatures from -30°C (cloud temperature) to 70°C (initial boiling temperature). |
- 15 An analysis of the amount of pollutants in the exhaust emission from a standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC +
- 20 EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 3, showed a reduction in the amounts of CO (g/km) of 18%; HC+NO_x (g/km) of 5.05% and particles (g/km) of 21.5%, compared to 100% Mk1 diesel fuel (SS 15 54 35).
- 25 An analysis of the amount of the pollutants in the exhaust emissions from a standard diesel truck engine, Engine Type: VOLVO D7C 290 EUR02 No. 1162 XX, power

kw/rpm = 213/2200 according to the Test Type: ECE R49
A30 Regulation for fuel composition 3, in comparison
with 100% Mk1 diesel fuel (SS 15 54 35), showed a
reduction in the amounts of: CO (g/kW) of 11%; HC+NO_x
5 (g/kW) of 4.8%, and particles (g/kw) of 17%.

The power (PkW) of the engine when operating on Motor
Fuel Composition 3 decreased only by 1.2%, and the fuel
consumption (l/kW) slightly increased by 0.5% in
10 comparison to the results obtained for the same engine
operating on 100% Mk1 diesel fuel (SS 15 54 35).

EXAMPLE 4

15 Motor Fuel Composition 4 demonstrated the effects of
operating a standard diesel engine with a fuel
composition of organic compounds containing bound
oxygen and a hydrocarbon liquid containing lighter
fractions of petroleum products in addition to diesel
20 fuel.

The content by volume of the components in the fuel
composition were as follows: ethanol - 8%; 1-butanol -
2%; diethyl acetaldehyde - 0.5%; ethyl acetate - 4%;
25 ethyl butyrate - 3%; acetaldehyde diethyl acetal -
0.5%; di-n-amyl ether - 8%; ethyl oleate - 8%;
tert-butyl peroxyacetate - 1%; hydrocarbon liquid -
65%; containing 15% kerosene and 50% Mk1 diesel fuel
(SS 15 54 35).

The fuel composition had the following characteristics:

- | | | |
|----|---|--|
| | Density at 20°C | 0.775 g/cm ³ |
| 5 | Temperature limits of evaporation of the liquid by boiling at atmospheric pressure: | |
| | up to 100°C | 12% |
| | up to 150°C | 19% |
| 10 | up to 200°C | 43% |
| | up to 285°C | 96% |
| | Heat of combustion | 40.2 MJ/kg |
| | Thermal stability | Motor Fuel Composition 4 is a homogeneous liquid stable at atmospheric pressure over a range of temperatures from -37°C (cloud temperature) to 70°C (initial boiling temperature). |
- 15 An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-W-DE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC +
- 20 EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 4, showed a reduction in the amounts of CO (g/km) of 27.7%, HC+NO_x (g/km) of 12.6% and particles (g/km) of 17% in comparison with 100% Mkl diesel fuel (SS 15 54 35).
- 25 When Motor Fuel Composition 4 was employed the operation of a standard diesel truck engine, engine

type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, the resulting measurements over the range of 1000 - 2600 rpm showed a decrease of less than 3.5% in power and torque values in comparison with the values obtained for the same engine operating on the 100% Mk1 diesel fuel (SS 15 54 35).

EXAMPLE 5

10

Motor Fuel Composition 5 demonstrated the effects of operating a standard engine with a fuel composition of organic compounds containing bound oxygen and a hydrocarbon liquid containing a kerosene fraction of petroleum products in addition to synthetic motor fuel.

15

The content by volume of the components in the fuel composition were as follows: 1-butanol - 1%; 2-ethyl hexanol - 3%; 2-ethylhexyl acetate - 1%; isoamyl alcohol - 1%; di-isoamyl ether - 2%; tetrahydrofurfuryl alcohol - 1.5%; iso-amyl nitrate - 0.5%; hydrocarbon liquid - 90%, containing 40% of kerosene and 50% synthin (a hydrocarbon mixture obtained from synthesis-gas with catalyst under atmospheric pressure and temperatures of 150 - 280 °C).

25

The fuel composition had the following characteristics:

Density at 20°C

0.805 g/cm³

Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

5	up to 100°C	0%
	up to 150°C	2%
	up to 200°C	43.5%
	up to 280°C	99%

Heat of combustion 43.3 MJ/kg

- 10 Thermal stability Motor Fuel Composition 5 is a homogeneous liquid stable at atmospheric pressure over a range of temperatures from -60°C (cloud temperature) to 70°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family

- 15 2D1-W-DE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 5, showed a reduction in the amounts of CO (g/km) of 12.6 %, HC+NO_x (g/km) of 7.4% and particles (g/km) of 20 26% in comparison with 100% Mk1 diesel fuel (SS 15 54 35).

When Motor Fuel Composition 5 was employed, the operation of a standard diesel truck engine, engine

- 25 type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, the resulting measurements over the range of 1000 - 2600 rpm showed less than a 17% decrease in power and torque values in

comparison with the values obtained for the same engine operating on the 100% Mk1 diesel fuel (SS 15 54 35).

- Similar results for power and exhaust emission changes were obtained when employing the Motor Fuel Composition 5 for operation of a standard aeroplane jet engine.

EXAMPLE 6

- 10 Motor Fuel Composition 6 demonstrated the possibility of using, for operating a standard diesel engine, a fuel composition of organic compounds containing bound oxygen and a hydrocarbon liquid in which the concentration of the hydrocarbon component in the
15 composition was less than 40% by volume.

- The content by volume of the components in Motor Fuel Composition 6 is: ethanol - 4.5%; propanol - 5.5%; hexanol - 15%; dibutyl ether - 8.5%; ethyl caprylate
20 -10%; dihexyl ether - 16%; di-tert-butyl peroxide - 1.5%; and hydrocarbon liquid (diesel fuel EN 590: 1993) - 39%.

- The fuel composition had the following characteristics:
25

Density at 20°C 0.819 g/cm³

- Temperature limits of evaporation by boiling of the liquid at
30 atmospheric pressure:

up to 100°C	10%
up to 150°C	20%

up to 200°C	39%
up to 370°C	98%
Heat of combustion	40.4 MJ/kg
Thermal stability	Motor Fuel Composition 6 was a homogeneous liquid stable at atmospheric pressure over a range of temperatures from -35°C (cloud temperature) to 78°C (initial boiling temperature).

5

An analysis of the amount of pollutants in the exhaust emission from a standard diesel engine of the Audi A6 TDI 1.9 automobile, model 1998 according to the Test Type - Modified European Driving Cycle (NEDC UDC +
 10 EUDC) ECE OICA (91/441/EEC), for Motor Fuel Composition 6, in comparison with 100% Mkl diesel fuel (EN 590: 1993), showed a reduction in the amounts of CO (g/km) of 0%, HC+NO_x g/km) of 14% and particles (g/km) of 46%.

15

EXAMPLE 7

Motor Fuel Composition 7 demonstrated the possibility of using, for operating a standard diesel engine, a fuel composition of organic compounds containing bound
 20 oxygen and a hydrocarbon liquid in which the concentration of the hydrocarbon component was less than 40% by volume, and wherein the hydrocarbon mixture was obtained from a liquid fraction obtained in mineral coal coking.

25

The content by volume of the components in Motor Fuel Composition 7 is: ethanol - 4.5%; propanol - 5.5%;

hexanol - 15%; dibutyl ether - 8.5%; ethyl caprylate -10%; dihexyl ether - 16%; 2-ethylhexylglycidyl ether - 1.5%; and hydrocarbon liquid - 39%, obtained from mineral coal processing, and including 9% of decalin.

5

The fuel composition had the following characteristics:

	Density at 20°C	0.820 g/cm ³
10	Temperature limits of evaporation by boiling of the liquid at atmospheric pressure:	
	up to 100°C	10%
	up to 150°C	18.5%
15	up to 200°C	39%
	up to 400°C	98%
	Heat of combustion	40.4 MJ/kg
	Thermal stability	Motor Fuel Composition 7 was a homogeneous liquid stable at atmospheric pressure over a range of temperatures from -35°C (cloud temperature) to 78°C (initial boiling temperature).
20	An analysis of the amount of pollutants in the exhaust emission from a standard diesel engine of the Audi A6 TDI 1.9 automobile, model 1998 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC), for Motor Fuel Composition	
25	7 in comparison with 100% diesel fuel (EN 590: 1993), showed a reduction in the amounts of CO (g/km) of 8%, HC+NO _x (g/km) of 12% and particles (g/km) of 45%.	

Similar results were obtained when employing the Motor Fuel Composition 7 for operation of a standard ship gas-turbine engine.

5

EXAMPLE 8

Motor Fuel Composition 8 demonstrated the possibility of using, for operating a diesel engine, a fuel composition made from a hydrocarbon liquid and from organic compounds containing bound oxygen that can be obtained by processing methanol and ethanol.

The content by volume of the components in Motor Fuel Composition 8 is: methanol - 1.5%; ethanol - 3%; formaldehyde dimethyl acetal - 2%; formaldehyde diethyl acetal - 3%; acetaldehyde diethyl acetal - 3%; methyl acetate - 1%; ethyl formate - 1%; rape seed oil methyl ester - 5%; ethyl oleate - 5%; tert-butyl peroxyacetate - 0.5%; hydrocarbon liquid (kerosene) - 75%.

20

The fuel compositions had the following characteristics:

	Density at 20°C	0.791 g/cm ³
25	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	11.5%
30	up to 150°C	15%
	up to 200°C	25%
	up to 280°C	97.5%

Heat of combustion	40.4 MJ/kg
Thermal stability	Fuel composition 8 was a homogeneous liquid stable at temperature from -48°C (cloud temperature) to 52.5°C (initial boiling temperature).

- An analysis of the amount of pollutants in the exhaust
- 5 emissions from a standard diesel engine of the VW
Passat TDI 1.9 automobile, model 1997, engine family
2Dl-WDE-95, power kW/rpm = 81/4150 according to the
Test Type - Modified European Driving Cycle (NEDC UDC +
EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition
- 10 8, in comparison with 100% Mkl diesel fuel (SS 15 54
35), showed a reduction in the amounts of CO (g/km) of
18%, HC+NO_x (g/km) of 8.6% and particles (g/km) of
31.6%.
- 15 The use of Motor Fuel Composition 8 for the operation
of a standard diesel truck engine, engine type VOLVO
TD61GS No. 0580026, with power and torque settings:
kW/Nm/rpm = 140/520/1900, for measurements over the
range of 1000 - 2600 rpm, showed less than a 4%
- 20 decrease in power and torque values in comparison with
the results obtained for the same engine operated with
100% Mkl diesel fuel (SS 15 54 35).

EXAMPLE 9

25

Motor Fuel Composition 9 demonstrated the possibility
of using, for operating a diesel engine, a fuel
composition made from organic compounds containing

bound oxygen that can be obtained by processing methanol and ethanol and a hydrocarbon liquid obtained in processing of turpentine and rosin.

- 5 The content by volume of the components in Motor Fuel Composition 9 is: methanol - 1.5%; ethanol - 3%; formaldehyde dimethyl acetal - 2%; formaldehyde diethyl acetal - 3%; acetaldehyde diethyl acetal - 3%; methyl acetate - 1%; ethyl formate - 1%; tall oil methyl ester - 10%, including methyl abietate - 3.5%; tert-butyl peroxyacetate - 0.5%; hydrocarbon liquid - 75% (a mixture of hydrocarbons obtained by processing turpentine and rosin, comprising methane - 45%, abiethane - 10%, and the remaining part of other terpene hydrocarbons).

The fuel compositions had the following characteristics:

20	Density at 20°C	0.821 g/cm ³
	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
25	up to 100°C	11.5%
	up to 150°C	15%
	up to 200°C	25%
	up to 400°C	98.75%
	Heat of combustion	40.4 MJ/kg

Thermal stability

Fuel composition 9 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -33°C (cloud temperature) to 52.5°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of the VW
5 Passat TDI 1.9 automobile, model 1997, engine family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC), for Motor Fuel Composition 9, in comparison with 100% Mkl diesel fuel (SS 15 54
10 35), showed a reduction in the amounts of CO (g/km) of 16%, HC+NO_x (g/km) of 10.5% and particles (g/km) of 40.5%.

The use of Motor Fuel Composition 9 for the operation
15 of a standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, for measurements over the range of 1000 - 2600 rpm, showed less than a 3% decrease in power and torque values in comparison with
20 the results obtained for the same engine operated with 100% Mkl diesel fuel (SS 15 54 35).

Similar results were obtained when employing the Motor Fuel Composition 9 for operation of a standard ship
25 gas-turbine engine.

EXAMPLE 10

Motor Fuel Composition 10 demonstrated the possibility of using, for operating a diesel engine, a fuel composition of a hydrocarbon liquid and of organic compounds containing bound oxygen that are not thoroughly purified technical products.

The content by volume of the components in the Motor Fuel Composition 10 is: ethanol - 4.5%; propanol - 12.5%; 1-butanol - 1%; isobutanol - 0.5%; 1-pentanol - 1.5%; 2-ethylhexanol - 9.5%; ethyl acetate - 1%; propyl acetate - 6%; isobutyl acetate - 0.1%; amyl acetate - 0.4%; butyl aldehyde - 0.8%; isobutyl aldehyde - 0.2%; dibutyl ether - 6.5%; di-octyl ether - 5%; n-amyl nitrate - 0.5%; and hydrocarbon liquid (diesel fuel SS 15 54 35 Mkl) - 50%.

The fuel composition had the following characteristics:

20

Density at 20°C	0.815 g/cm ³
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Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

25

up to 100°C	25%
up to 150°C	35%
up to 200°C	50%
up to 285°C	97.5%

30

Heat of combustion	39.0 MJ/kg
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Self-ignition temperature	300°C
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Thermal stability: Motor Fuel Composition 10 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -35°C (cloud temperature) to 64°C (initial boiling temperature).

- An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of the VW GOLF
- 5 CL DIESEL automobile, Engine Family: D1-W03-92 when executing Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 10, in comparison with the results obtained for 100% Mkl diesel fuel (SS 15 54 35), showed a
- 10 reduction in the amounts of CO (g/km) of 16.9%, HC+NO_x (g/km) of 5.9% and particles (g/km) of 23.7%.

- The use of Motor Fuel Composition 10 for the operation of a standard diesel truck engine, engine type VOLVO
- 15 TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, for measurements over the range of 1000 - 2600 rpm, showed less than a 5% decrease in the values of power and torque of less than 5% in comparison with the corresponding values obtained
- 20 for the same engine operating with 100% Mkl diesel fuel (SS 15 54 35).

EXAMPLE 11

- 25 Motor Fuel Composition 11 demonstrated the possibility of using, for operating a standard diesel engine, a fuel composition of organic compounds containing bound

oxygen that are not thoroughly purified technical products and a hydrocarbon component comprising kerosene, synthin, hydrogenated turpentine and a hydrogenated liquid fraction obtained in mineral coal coking.

The content by volume of the components in the Motor Fuel Composition 11 is: ethanol - 4.5%; propanol - 12.5%; 1-butanol - 1%; isobutanol - 0.5%; 1-pentanol - 1.5%; 2-ethylhexanol - 9.5%; ethyl acetate - 1%; propyl acetate - 6%; isobutyl acetate - 0.1%; amyl acetate - 0.4%; butyl aldehyde - 0.8%; isobutyl aldehyde - 0.2%; dibutyl ether - 6.5%; di-octyl ether - 5%; n-amyl nitrate - 0.5%; and hydrocarbon liquid (comprising a terpene fraction - 10%, including menthane - 8%; kerosene - 10% and synthin - 20%, including linear saturated hydrocarbons - 18%, and a hydrogenated liquid fraction obtained in mineral coal coking - 10%, including decalin - 2%) - 50%.

The fuel composition had the following characteristics:

	Density at 20°C	0.815 g/cm ³
25	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	25%
	up to 150°C	35%
30	up to 200°C	50%
	up to 400°C	98.5%
	Heat of combustion	39.0 MJ/kg

Self-ignition temperature 300°C

Thermal stability: Motor Fuel Composition 11 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -35°C (cloud temperature) to 64°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of the VW GOLF CL DIESEL automobile, Engine Family: DL-W03-92 when executing Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 11, in comparison with the results obtained for 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amounts of CO (g/km) of 16.9%, HC+NO_x (g/km) of 5.9% and particles (g/km) of 23.7%.

The use of Motor Fuel Composition 11 for the operation of a standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, for measurements over the range of 1000 - 2600 rpm, showed less than a 5% decrease in power and torque values in comparison with the corresponding values obtained for the same engine operating with 100% Mk1 diesel fuel (SS 15 54 35).

EXAMPLE 12

Motor Fuel Composition 12 demonstrated the possibility of using, for operating a standard diesel engine, a fuel composition of a hydrocarbon liquid and organic

compounds containing bound oxygen that is useful at elevated temperatures.

The content by volume of components in Motor Fuel

- 5 Composition 12 is: 1-octanol - 2%; ethyl oleate - 4%; ethyl caprylate - 2.5%; di-n-amyl ether 4%; di-octyl ether - 15%; acetaldehyde dibutyl acetal 2%; cyclohexyl nitrate - 0.5%; and hydrocarbon liquid (Mk1 diesel fuel SS 15 54 35) - 70%.

10

The fuel composition had the following characteristics:

Density at 20°C 0.816 g/cm³

- 15 Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

up to 100°C 0%

up to 150°C 0%

- 20 up to 200°C 19.5%

up to 285°C 96.5%

Flash point not lower than 50°C

Heat of combustion 42.5 MJ/kg

Thermal stability: Motor Fuel Composition 12 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -36°C (cloud temperature) to 184°C (initial boiling temperature).

25

An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of the VW GOLF

CL DIESEL automobile, engine family: D1-W03-92
according to Test Type - Modified European Driving
Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor
Fuel Composition 12, showed a reduction of CO (g/km) of
5 16%, HC+NO_x (g/km) of 7.5% and particles (g/km) of 18.5%
in comparison with the results obtained for 100% Mk1
diesel fuel (SS 15 54 35).

An analysis of the amount of pollutants in the exhaust
10 emissions from a standard diesel engine of a truck,
engine type: VOLVO D7C 290 EUR02 No: 1162 XX, power
kW/rpm = 213/2200 according to the Test Type: ECE R49
A30 Regulation, for Motor Fuel Composition 12 in
comparison to 100% Mk1 diesel fuel (SS 15 54 35),
15 showed a reduction in the amounts of CO (g/kW) of 12%,
HC+NO_x (g/kW) of 5.0%, particles (g/kW) of 17.5%.

The power (PkW) of the engine operated on Motor Fuel
Composition 12 did not change and the fuel consumption
20 (l/kW) did not increase in comparison with the results
obtained for the same engine operated with 100% Mk1
diesel fuel (SS 15 54 35).

EXAMPLE 13

25 Motor Fuel Composition 13 demonstrated the possibility
of using, for operating a standard diesel engine, a
fuel composition of a hydrocarbon liquid and organic
compounds containing bound oxygen useful at elevated
30 temperatures, which has a flash point not lower than
100°C.

The content by volume of components in Motor Fuel Composition 13 is: 1-octanol - 2%; ethyl oleate - 4%; ethyl caprylate - 2.5%; di-n-amyl ether 4%; di-octyl ether - 15%; acetaldehyde dibutyl acetal 2%; cyclohexyl nitrate - 0.5%; and hydrocarbon liquid (gas oil) - 70%.

The fuel composition had the following characteristics:

	Density at 20°C	0.826 g/cm ³
10	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	0%
15	up to 150°C	0%
	up to 200°C	18%
	up to 400°C	98%
	Flash point	not lower than 100°C
	Heat of combustion	42.5 MJ/kg
20	Thermal stability:	Motor Fuel Composition 13 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -20°C (cloud temperature) to 184°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of the VW GOLF CL DIESEL automobile, engine family: D1-W03-92

25 according to Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 13, showed a reduction in comparison

with the results obtained for 100% Mk1 diesel fuel (SS 15 54 35) of: CO (g/km) of 6.9%, HC+NO_x (g/km) of 2.3% and particles (g/km) of 2.5%.

- 5 An analysis of the amount of pollutants in the exhaust emissions from a standard diesel engine of a truck, engine type: VOLVO D7C 290 EUR02 No: 1162 XX, power kW/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation, for Motor Fuel Composition 13 in
- 10 comparison with 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amounts of CO (g/kW) of 0%, HC+NO_x (g/kW) of 0%, particles (g/kW) of 0%.

- The power (PkW) of the engine operated on Motor Fuel
- 15 Composition 13 did not change and the fuel consumption (l/kW) did not increase in comparison with the results obtained for the same engine operated with 100% Mk1 diesel fuel (SS 15 54 35).

20 EXAMPLE 14

- Motor Fuel Composition 14 demonstrated the possibility of using, for operating a diesel engine, a fuel composition of a hydrocarbon liquid and of organic
- 25 compounds containing bound oxygen that is effective at reduced operating temperatures.

- The content by volume of the components in the fuel composition were: ethanol - 10%; acetaldehyde diethyl
- 30 acetal - 2.5%; dibutyl ether - 10%; di-isoamyl ether - 6.5%; butyl butyrate - 3.5%; methyltetrahydrofuran -

5%; isoamyl acetate - 2%; isoamyl nitrate - 0.5%; and hydrocarbon liquid (Mk1 diesel fuel SS 15 54 35) - 60%.

The fuel composition had the following characteristics:

5

Density at 20°C 0.807 g/cm³

Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

10

up to 100°C	15%
up to 150°C	30%
up to 200°C	41.5%
up to 285°C	96.5%

15 Heat of combustion 40.4 MJ/kg

Thermal stability Motor Fuel 14 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -40°C (cloud temperature) to 78°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emissions of a standard diesel engine of the VW GOLF CL

20 DIESEL automobile, engine family: D1-W03-92 when testing Motor Fuel Composition 14 according to the Test Type - Modified European Driving Cycle (NEDC UDC + FUDC) FCF OICA (91 /441 /EEC), in comparison with the results obtained for 100% Mk1 diesel fuel (SS 15 54

25 35), showed a reduction in the amounts of: CO (g/kW) of 16.9%, HC+NO_x (g/kw) of 8.8%, and particles (g/kW) of 20.5%.

The use of Motor Fuel Composition 14 for operating a standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, for measurements over the range of 1000 - 2600 rpm, showed less than a 3.5% decrease in power and torque values in comparison with the values obtained for the same engine operated with 100% Mk1 diesel fuel (SS 15 54 35).

10

EXAMPLE 15

Motor Fuel Composition 15 demonstrated the possibility of using, for operating a standard diesel engine and a standard jet engine, a fuel composition of a hydrocarbon liquid and of organic compounds containing bound oxygen that is effective at reduced operating temperatures. The hydrocarbon liquid of the Motor Fuel Composition 15 is a mixture of hydrocarbons yielded in processing of gaseous C₂ to C₅ hydrocarbons.

20

The content by volume of the components in the fuel composition were: ethanol - 8%; methanol - 1%; dibutyl ether - 6%; di-isoamyl ether - 8%; butyl butyrate - 3.5%; tetrahydrofurfuryl alcohol - 5%; isoamyl acetate - 2%; isoamyl nitrate - 0.5%; and hydrocarbon liquid (C₆-C₁₄ hydrocarbons mixture, including not less than 45% of linear hydrocarbons) - 65%.

The fuel composition had the following characteristics:

	Density at 20°C	0.790 g/cm ³
5	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	9%
	up to 150°C	17%
10	up to 200°C	50%
	up to 280°C	98%
	Heat of combustion	42.4 MJ/kg
	Thermal stability	Motor Fuel Composition 15 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -70°C (cloud temperature) to 64.5°C (initial boiling temperature).
15	An analysis of the amount of pollutants in the exhaust emissions of a standard diesel engine of the VW GOLF CL DIESEL automobile, engine family: D1-W03-92 when testing Motor Fuel Composition 15 according to the Test Type - Modified European Driving Cycle (NEDC UDC +	
20	FUDC) FCF OICA (91 /441 /EEC), in comparison with the results obtained for 100% Mkl diesel fuel (SS 15 54 35), showed a reduction in the amounts of: CO (g/kW) of 26.3%, HC+NO _x (g/kw) of 12.6%, and particles (g/kw) of 31.8%.	

25

The use of Motor Fuel Composition 15 for operating a standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm

= 140/520/1900, for measurements over the range of 1000
- 2600 rpm, showed less than a 4.5% decrease in power
and torque values in comparison with the values
obtained for the same engine operated with 100% Mk1
5 diesel fuel (SS 15 54 35).

Similar results for power and exhaust emission changes
were obtained when employing the Motor Fuel Composition
15 for operation of a standard aeroplane jet engine.

10

EXAMPLE 16

Motor Fuel Composition 16 demonstrates the possibility
of using, for operating a diesel engine, a fuel
15 composition for a diesel engine that contains a
hydrocarbon liquid and organic compounds containing
bound oxygen, as well as 1% of water, without adversely
affecting its operating characteristics and without
compromising the stability of the system.

20

The content by volume of the components in the Motor
Fuel Composition 16 is: water - 1%; ethanol - 9%;
di-ethoxypropane - 1%; 1-butanol - 4%; methyl butyrate
- 4%; 2-ethylhexanol - 20%; methyltetrahydropyran - 5%;
25 dihexyl ether - 5%; isopropyl nitrate - 1%; and
hydrocarbon liquid (Mk1 diesel fuel SS 15 54 35) - 50%.

The fuel composition had the following characteristics:

	Density at 20°C	0.822 g/cm ³
5	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	10%
	up to 150°C	30%
10	up to 200°C	50%
	up to 285°C	97.5%
	Heat of combustion	39.4 MJ/kg
	Thermal stability	Motor Fuel Composition 16 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -36°C (cloud temperature) to 78°C (initial boiling temperature).
15	An analysis of the amount of pollutants in the exhaust emission of a standard diesel engine of the Cardiovascular VW Passat TDI 1.9 model 1997, engine family 2Dl-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC	
20	UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 16, in comparison with 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amount of: CO (g/km) - 22.4%, HC+NO _x (g/km) - 0% and particles (g/km) - 6.9%.	

An analysis of the amount of pollutants in the exhaust emission of the standard diesel truck engine, engine type: VOLVO D7C 290 EUR02 No. 1162 XX, power kW/rpm = 213/2200 according to the Test Type: ECE R49 A30

- 5 Regulation, for Motor Fuel composition 16, showed the following results in comparison with 100% Mkl diesel fuel (SS 15 54 35) - reduction in the amounts of: CO (g/kW) - 6%, HC+NO_x (g/kW) - 0%, particles (g/kW) - 11%.
- 10 The power (PkW) of this diesel truck engine operated on Motor Fuel Composition 16 decreased only 3% and fuel consumption (l/kw) increased only 2% in comparison with the results obtained for the same engine working on 100% Mkl diesel fuel (SS 15 54 35).

15

EXAMPLE 17

- Motor Fuel Composition 17 demonstrates the possibility of using, for operating a standard diesel engine and a
- 20 standard ship gas-turbine engine, a fuel composition containing a hydrocarbon liquid and organic compounds containing bound oxygen, as well as 1% of water, without adversely affecting its operating characteristics and without compromising the stability
- 25 of the system. Both the hydrocarbon component and the oxygen-containing components of this composition are obtained from vegetation processing.

- The content by volume of the components in the Motor
- 30 Fuel Composition 17 is: water - 1%; ethanol - 9%; di-ethoxypropane - 1%; 1-butanol - 4%; methyl butyrate - 4%; 2-ethylhexanol - 12%; methyl-epoxytallowate - 5%;

diisobutyl ketone - 3%; methyltetrahydropyran - 5%;
dibutyl ether - 5%; isopropyl nitrate - 1%; and
hydrocarbon liquid (synthin derived from synthesis-gas
obtained from cellolignine originating from vegetation)
5 - 50%.

The fuel composition had the following characteristics:

	Density at 20°C	0.822 g/cm ³
10	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	10%
15	up to 150°C	30%
	up to 200°C	50%
	up to 400°C	99.5%
	Heat of combustion	39.4 MJ/kg
20	Thermal stability	Motor Fuel Composition 17 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -36°C (cloud temperature) to 78°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emission of a standard diesel engine of the
Cardiovascular VW Passat TDI 1.9 model 1997, engine
25 family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 17, in comparison with 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amount of: CO

(g/km) - 18.1%, HC+NO_x (g/km) - 1.2% and particles
(g/km) - 23.4%.

An analysis of the amount of pollutants in the exhaust
5 emission of a standard diesel truck engine, engine
type: VOLVO D7C 290 EUR02 No. 1162 XX, power kW/rpm =
213/2200 according to the Test Type: ECE R49 A30
Regulation, for Motor Fuel composition 17, showed the
following results in comparison with 100% Mk1 diesel
10 fuel (SS 15 54 35) - reduction in the amounts of: CO
(g/kW) - 12%, HC+NO_x (g/kW) - 0%, particles (g/kW) -
13.5%.

The power (P_{kW}) of this diesel truck engine operated on
15 Motor Fuel Composition 17 decreased only 3% and fuel
consumption (l/kw) increased only 2% in comparison with
the results obtained for the same engine working on
100% Mk1 diesel fuel (SS 15 54 35).

20 Similar results were obtained when employing the Motor
Fuel Composition 17 for operation of a standard ship
gas-turbine engine.

EXAMPLE 18

25 Motor Fuel Composition 18 illustrates a fuel
composition for standard diesel and gas-turbine engines
formed entirely from organic compounds containing bound
oxygen, all of which may be produced from renewable raw
30 material of plant origin. No diesel, kerosene, gas oil
or other hydrocarbon fraction was present.

The content by volume of the components in the fuel composition is: ethanol - 1%; 1-butanol - 4%; 2-ethylhexaldehyde - 10%; acetaldehyde dibutyl acetal - 6%; di-2-ethylhexyl ether - 18%; di-octyl ether - 20%;
 5 di-n-amyl ether - 4%; dibutyl ether - 7%; ethyl oleate - 16%; rape seed oil methyl ester - 13.5%; and di-tert-butyl peroxide - 0.5%.

The fuel composition had the following characteristics:

10	Density at 20°C	0.830 g/cm ³
	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
15	up to 100°C	1%
	up to 150°C	12.5%
	up to 200°C	50%
	up to 370°C	95.5%
20	Heat of combustion	40.6 MJ/kg
	Self-ignition temperature	150°C
	Thermal stability	Motor Fuel Composition 18 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -20°C (cloud temperature) to 78°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust
 25 emission of a standard diesel engine of the VW Passat TDI 1.9 model 1997 automobile, engine family 2D1-WDE-95, power kW/rpm = 81/4150 according to the

Test Type -Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 18, in comparison with 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amount of: CO (g/km) - 5.5%; HC+NO_x (g/km) - 8.5% and particles (g/km) - 17.2%.

An analysis of the amount of pollutants in the exhaust emission of a standard diesel truck engine, engine type: VOLVO D7C 290 EUR02 No. 1162 XX, power kW/rpm = 213/2200 when executing Test Type: ECE R49 A30 Regulation, for Motor Fuel Composition 18, showed the following results in comparison with 100% Mk 1 diesel fuel (SS 15 54 35) - a reduction in the amounts of CO (g/kW) of 0%; HC+NO_x (g/kW) of 0%, and particles (g/kW) of 0%.

The power (P_{kW}) of this diesel truck engine operated on Motor Fuel Composition 18 did not change nor did fuel consumption l/kW change in comparison with the same engine operating on 100% Mk1 diesel fuel (SS 15 54 35). Similar results were obtained when employing the Motor Fuel Composition 18 for operation of a standard ship gas-turbine engine. These results illustrate how the instant invention provides a unique and effective motor fuel composition for diesel engines that does not require a typical heavier hydrocarbon fraction, such as diesel fuel.

EXAMPLE 19

Motor Fuel Composition 19 illustrates a fuel composition formed entirely from oxygen containing

compounds, and characterized by good performance properties, including a flash point of 32°C.

The content by volume of the components in the fuel composition is: 1-butanol - 5%; 2-ethylhexaldehyde - 8%; acetaldehyde dibutyl acetal - 6%; di-2-ethylhexyl ether - 18%; di-octyl ether - 20%; di-n-amyl ether - 4%; dibutyl ether - 7%; ethyl oleate - 16%; rape seed oil methyl ester - 12.0%; and ethylamyl ketone - 2%, 1,2-epoxy-4-epoxycyclohexane - 2%.

The fuel composition had the following characteristics:

	Density at 20°C	0.831 g/cm ³
15	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	0%
20	up to 150°C	12.0%
	up to 200°C	48%
	up to 285°C	95.5%
	Heat of combustion	40.7 MJ/kg
	Flash point	32°C
25	Self-ignition temperature	150°C
	Thermal stability	Motor Fuel Composition 19 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -30°C (cloud temperature) to 117°C (initial boiling temperature).

- An analysis of the amount of pollutants in the exhaust emission of a standard diesel engine of the VW Passat TDI 1.9 model 1997 automobile, engine family 2D1-WDE-95, power kW/rpm = 81/4150 according to the
- 5 Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 19, in comparison with 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amount of: CO (g/km) - 7.5%; HC+NO_x (g/km) - 7.5% and particles (g/km) - 18.2%.

10

- An analysis of the amount of pollutants in the exhaust emission of a standard diesel truck engine, engine type: VOLVO D7C 290 EUR02 No. 1162 XX, power kW/rpm = 213/2200 when executing Test Type: ECE R49 A30
- 15 Regulation, for Motor Fuel Composition 19, showed the following results in comparison with 100% Mk 1 diesel fuel (SS 15 54 35) - a reduction in the amounts of CO (g/kW) of 8%; HC+NO_x (g/kW) of 6%, and particles (g/kW) of 15%

20

Similar results were obtained when employing the Motor Fuel Composition 19 for operation of a standard ship gas-turbine engine.

25

EXAMPLE 20

- Motor Fuel Composition 20 demonstrates the effects of operating a standard diesel, turbojet and gas-turbine engines with a fuel composition entirely formed of
- 30 organic compounds containing bound oxygen, stable over a wide range of ambient temperature and tolerant to presence of water. The fuel composition is

characterised by good performance properties and produces exhaust emissions with a very low content of pollutants.

- 5 The content by volume of the components in Motor Fuel Composition 20 is as follows: isoamyl alcohol - 2%; diisoamyl ether -5%; cyclopentanone - 2.5%; cyclohexyl nitrate - 0.5%; 1.2-epoxy-4-epoxy-cyclohexane - 10%; isobornyl methacrylate - 20% and
- 10 2,6,8-trimethyl-4-nonanol - 60%.

The fuel composition had the following characteristics:

	Density at 20°C	0.929 g/cm ³
15	Temperature limits of evaporation by boiling of The liquid at atmospheric pressure:	
	up to 100°C	0%
20	up to 150°C	4.5%
	up to 200°C	10%
	up to 280°C	99.9%
	Flash point, not lower than	42°C
25	Self ignition point	185°
	Heat of combustion	39.6 MJ/kg
	Thermal stability	Motor Fuel Composition 20 is a homogeneous liquid, stable at atmospheric pressure over a range of temperatures from -55°C (cloud temperature) to 131°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emission from a standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family

- 5 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 20, in comparison with 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amounts of CO (g/km) of
- 10 62.3%; HC+NO_x (g/km) of 23.5% and particles (g/km) of 54.2%.

An analysis of the amount of the pollutants in the exhaust emissions from a standard diesel truck engine,

- 15 Engine Type: VOLVO D7C 290 EUR02 No. 1162 XX, power kW/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation for fuel composition 20, in comparison with 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amounts of: CO (g/kW) of 38.2%; HC+NO_x
- 20 (g/kW) of 16.8%, and particles (g/kW) of 49.3%.

The power (P_{kW}) of the engine when operating on Motor Fuel Composition 20 increased by 2%, and the fuel consumption (l/kW) decreased by 3%.

25

Similar results of the reduction of pollutants in the exhaust emissions were obtained when employing the Motor Fuel Composition 20 for operation of a standard ship gas-turbine engine and standard airplane turbojet

30 engine.

Motor Fuel Composition 20 is immiscible with water and does not adopt almost any amounts of water. When Motor Fuel Composition 20 is intensively mixed with water by mechanical means, an emulsion is obtained. After the mixing is stopped, a separate layer of water is obtained at the bottom of the tank, and the unaffected motor fuel forms an upper layer in the tank.

EXAMPLE 21

10

Motor Fuel Composition 21 demonstrated the possibility of increasing the stability of a fuel comprising ordinary kerosene containing some amount of water at lower temperatures.

15

The content by volume of components in Motor Fuel Composition 21 is: tetrahydrofurfuryl alcohol - 3%; tertbutylperoxyacetate - 2%, hydrocarbon liquid (kerosene with a cloud point of -46°C) - 95%.

20

The fuel composition had the following characteristics:

Density at 20°C	0.791 g/cm^3
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25 Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

up to 100°C	0%
up to 150°C	0%
up to 200°C	18%
up to 220°C	99.99%

Heat of combustion	43.3 MJ/kg
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Thermal stability: Motor Fuel Composition 21 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -60°C (cloud temperature) to 178°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emission from a standard diesel engine of the VW Passat
5 TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 21, in comparison with 100% Mk1 diesel fuel (SS 15 54
10 35), showed a reduction in the amounts of CO (g/km) of 25%; HC+NO_x (g/km) of 3.5% and particles (g/km) of 30%.
Similar results were obtained when employing the Motor Fuel Composition 21 for operation of a standard
15 airplane turbojet engine.

EXAMPLE 22

Motor Fuel Composition 22 demonstrated a possibility,
20 of inter alia, eliminating a lubrication additive from the composition of a hydrocarbon component of the fuel.

The content by volume of components in Motor Fuel Composition 22 is: methylepoxytallowate - 10%;
25 tetrahydrofurfuryl alcohol - 0.5%, hydrocarbon liquid (Mk1-type fuel without lubricating additive) - 89.5%.

The fuel composition had the following characteristics:

	Density at 20°C	0.821 g/cm ³
5	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	0%
	up to 150°C	0%
10	up to 200°C	25%
	up to 350°C	98%
	Heat of combustion	42.6 MJ/kg
	Thermal stability:	Motor Fuel Composition 22 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -30°C (cloud temperature) to 177°C (initial boiling temperature).

15

An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the

- 20 Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 22, in comparison with 100% Mk1 diesel fuel (SS 15 54 35), showed a reduction in the amounts of CO (g/km) of 3.6%; HC+NO_x (g/km) of 1.2% and particles (g/km) of 10.5%.

Similar results were obtained when employing the Motor Fuel Composition 22 for operation of a standard ship gas-turbine engine.

5

EXAMPLE 23

Motor Fuel Composition 23 demonstrated the possibility of eliminating an anti-deposit additive from the base diesel fuel.

10

The content by volume of components in Motor Fuel Composition 23 is: tetrahydrofurfurylacetate - 10%; acetoacetaldehyde-1,1-dimethylacetal - 0.5%, hydrocarbon component (EN590:1993-type fuel without anti-deposit additive) - 89.5%.

15

The fuel composition had the following characteristics:

	Density at 20°C	0.837 g/cm ³
20	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	0%
25	up to 150°C	0%
	up to 200°C	20%
	up to 370°C	98.5%
	Heat of combustion	41.26 MJ/kg

Thermal stability: Motor Fuel Composition 23 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -30°C (cloud of temperature) to 190°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the VW
5 Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 23, in comparison with 100% diesel fuel (EN590:1993),
10 showed a reduction in the amounts of CO (g/km) of 9.5%; HC+NO_x (g/km) of 2% and particles (g/km) of 17.3%.

Similar results were obtained when employing the Motor Fuel Composition 23 for operation of a standard ship
15 gas-turbine engine.

EXAMPLE 24

Motor Fuel Composition 24 demonstrated a possibility of
20 eliminating completely the need for a hydrocarbon component in a motor fuel composition by using two oxygen-containing compounds and to obtain the required performance parameters without use of any hydrocarbon component.

The content by volume of components in Motor Fuel Composition 24 is: butylepoxystearate - 50%; ethyleneglycolmono-2-ethylhexyl ether - 50%.

- 5 The fuel composition had the following characteristics:

	Density at 20°C	0.898 g/cm ³
10	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	0%
	up to 150°C	0%
	up to 220°C	20%
15	up to 250°C	99.95%
	Flash point	115 °C
	Thermal stability:	Motor Fuel Composition 24 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -30°C (cloud of temperature) to 200°C (initial boiling temperature).

- 20 An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition
- 25 24, in comparison with 100% diesel fuel (EN590:1993), showed a reduction in the amounts of CO (g/km) of 32.4%; HC+NO_x (g/km) of 21.8% and particles (g/km) of 52.6%.

EXAMPLE 25

Motor fuel composition 25 demonstrated the possibility of using, for the operation of a diesel engine, a fuel composition consisting of a hydrocarbon liquid and organic compounds containing bound oxygen that is expedient when used at reduced ambient temperatures.

- The contents by volume of the components in the fuel in
- 10 Motor Fuel Composition 25 are ethanol 10%, acetaldehyde diethyl acetal 2.5%, dibutyl ether 5%, di-isoamyl ether 6.5%, butyl butyrate 3.5%, methyltetrahydrofuran 5%, isoamyl acetate 2%, amyl nitrate 0.5%, hydrocarbon liquid (Mk1 diesel fuel SS 15 54 35) 65%.
- 15 The fuel composition had the following characteristics:

	Density at 20°C	0.811 g/cm ³
	Temperature limits of evaporation of the	
20	liquid by boiling at atmospheric pressure:	
	up to 100°C	15%
	up to 150°C	25%
	up to 200°C	41.5%
25	up to 285°C	96.5%
	Heat of combustion	40.4 MJ/kg

Thermal stability

Motor Fuel 25 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -40°C (cloud temperature) to 78°C (initial boiling temperature).

- An analysis of the amount of pollutants in the exhaust emissions of a standard diesel engine of the VW GOLF CL
- 5 DIESEL automobile, engine family: D1-W03-92 when testing Motor Fuel Composition 25 according to the Test Type - Modified European Driving Cycle (NEDC UDC + FUDC) FCF OICA (91 /441 /EEC), in comparison with the results obtained for 100% Mk1 diesel fuel (SS 15 54
- 10 35), showed a reduction in the amounts of: CO (g/kW) of 16.9%, HC+NO_x (g/kw) of 8.8%, and particles (g/kW) of 20.5%.

- The use of Motor Fuel Composition 25 for operating a
- 15 standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, for measurements over the range of 1000 - 2600 rpm, showed less than a 3.5% decrease in power and torque values in comparison with the values
- 20 obtained for the same engine operated with 100% Mk1 diesel fuel (SS 15 54 35).

- Each of the Motor Fuel Compositions 1 - 25 was prepared by adding the required amount of components in the same
- 25 tank at the same temperature in a pre-determined order, starting with the component having (at that temperature) the lowest density and ending with the

component having the highest density, and holding the resulting mixture for at least one hour prior to use.

Example 1 defines a minimum concentration of organic compounds containing bound oxygen in the mixture with a hydrocarbon component, to achieve the advantages of the present invention.

Examples 2 to 9, 13, 15, and 17 demonstrate the possibility of achieving the positive effect of this invention irrespective of the composition of the hydrocarbon component, i.e., that the invention enables employing various hydrocarbon liquids sold presently on the market.

Examples 4, 5, 8, and 11 demonstrate the possibility of producing the motor fuels for diesel engines using a petroleum kerosene fraction. These fuels can also be used for jet engines. Moreover, examples 5, 8 and 15 demonstrate that the fuel of the invention comprising a particular hydrocarbon component remains stable at temperatures as low as -70°C . This property is not demonstrated by any of the fuel formulations revealed by the prior art.

Examples 4, 10, and 11 demonstrate that the present invention enables mixing over an extremely wide range of concentrations of organic compounds containing bound oxygen and a hydrocarbon liquid, wherein no engine modification is required.

Examples 7 and 11 demonstrate the possibility of using hydrocarbons yielded in mineral coal processing as a hydrocarbon component of the motor fuel.

- 5 Examples 8 and 9 demonstrate the possibility of using methanol and ethanol as a raw material for oxygen-containing compounds required for producing the novel motor fuel of this invention. Both methanol and ethanol are largely produced in many countries of the
- 10 world. Thus, the novel fuel of this invention has a good potential for raw materials. Majority of the organic compounds containing bound oxygen needed for manufacture of the fuel of this invention are presently produced on an industrial scale. Therefore, production
- 15 of the motor fuel of this invention is feasible and can be initiated within a short period of time.

- Examples 10 and 11 demonstrate the possibility of using, for producing of a motor fuel, an organic
- 20 compound containing bound oxygen that is not thoroughly purified and may contain by-products. This simplifies the production technology and makes the constituents compounds cheaper and more accessible.
- 25 Examples 12 and 13 demonstrate the possibility of formulating the novel motor fuel stable over a wide temperature range, from -36°C to $+184^{\circ}\text{C}$. It should be stressed, that when the temperature is changed to a value outside the above-mentioned range, the fuel of
- 30 this invention will again form a single, stable and homogeneous phase after it has been allowed to return to temperatures within the range of -36°C to $+184^{\circ}\text{C}$,

between the cloud point and starting boiling point. The examples also demonstrate that the fuels have a high flash point, making them safer and simpler in transportation, handling and distribution.

5

Examples 5, 8, 14, 15 and 25 demonstrate the possibility of formulating the novel motor fuel operating at ambient temperatures below 0°C. Moreover, the hydrocarbon fraction obtained in processing of
10 gaseous C₂-C₅ hydrocarbons can be used for producing the motor fuel of this invention.

Examples 16 and 17 demonstrate the possibility of producing the novel motor fuel that is tolerant
15 regarding the presence of water. The volume content of water of up to 1% does not affect the stability of the fuel even at temperatures as low as -36°C. This is an extremely important feature of this invention. The motor fuel of this invention does not require
20 thoroughly dehydrated oxygen-containing compounds for its production, making manufacturing cheaper and simpler. Moreover, example 17 demonstrates the possibility of employing hydrocarbons yielded in processing of vegetation as a fuel component. The
25 latter feature enables formulation of the motor fuel formed entirely from renewable components.

Examples 18, 19 and 20 demonstrate the possibility of producing the novel motor fuel for standard engines
30 comprising oxygen-containing compounds only, without using any hydrocarbons. Such a fuel was never before revealed. Even specially designed ethanol fuel engines

require a certain amount of hydrocarbons in the fuel to improve ignition.

Examples 21-24 demonstrate, inter alia, that the
5 requested combination of four functional groups can be
achieved by employing two compounds. Example 24
demonstrates the possibility of producing the novel
motor fuel for standard engines comprising only two
oxygen-containing compounds without using any
10 hydrocarbons.

Other variations of the invention are possible, as will
be clear to those of ordinary skill in the art, such
as, for example, using only three compounds. This
15 invention is not limited to the examples set forth
herein.